

## CLAIMS

What is claimed is:

1. A method for transporting gas, comprising:  
dissolving the gas in an emulsion comprising a fluorinated hydrocarbon, a surfactant and an aqueous electrolyte with a pH of at most 4 or at least 9; and  
contacting the emulsion with an electrode.
2. The method of claim 1, wherein:  
the aqueous electrolyte has a pH of at most 3.
3. The method of claim 1, wherein:  
the aqueous electrolyte comprises an acid dissolved in water, and the acid comprises a member selected from the group consisting of:  
 $\text{H}_2\text{SO}_4$ ,  $\text{HNO}_3$ ,  $\text{HClO}_4$ ,  $\text{H}_3\text{PO}_3$ ,  $\text{H}_3\text{PO}_4$ ,  $\text{HCl}$ ,  $\text{HBr}$ ,  $\text{HI}$ ,  $\text{CH}_3\text{CO}_2\text{H}$ ,  $\text{CCl}_3\text{CO}_2\text{H}$ ,  $\text{CF}_3\text{CO}_2\text{H}$ , and mixtures thereof.
4. The method of claim 1, wherein:  
the aqueous electrolyte comprises an aqueous solution of  $\text{H}_2\text{SO}_4$ .
5. The method of claim 1, wherein:  
the aqueous electrolyte has a pH of at least 10.
6. The method of claim 1, wherein:  
the aqueous electrolyte comprises a base dissolved in water, and the base comprises a member selected from the group consisting of:  
 $\text{LiOH}$ ,  $\text{NaOH}$ ,  $\text{KOH}$ ,  $\text{Rb(OH)}$ ,  $\text{CsOH}$ ,  $\text{Mg(OH)}_2$ ,  $\text{Ca(OH)}_2$ ,  $\text{Sr(OH)}_2$ , and  $\text{Ba(OH)}_2$ , and mixtures thereof.
7. The method of claim 1, wherein:

the fluorinated solvent is selected from the group consisting of:

$(C_nF_{2n+1})Si(OCH_3)_3$ ;  $(C_nF_{2n+1})_2Si(OCH_3)_2$ ;  $(C_nF_{2n+1})CH_2OC(O)CH_3$ ;  
 $CF_3[OCF_2CF_2]_nOCF_3$ ;  $CF_3[OCF_2CF_2]_nOCF_2Cl$ ;  $CF_3[OCF_2CF_2]_nOCF_2Br$ ;  
 $CF_3[OCF_2CF_2]_nCF_2H$ ;  $CF_3[OCF_2CF_2]_nF$ ;  $CF_3[OCF_2CF_2]_nCl$ ;  $CF_3[OCF_2CF_2]_nBr$ ;  
 $CF_3[OCF_2CF_2]_nH$ ;  $CF_3CF_2[OCF_2CF_2]_nF$ ;  $CF_3CF_2[OCF_2CF_2]_nCl$ ;  $CF_3CF_2[OCF_2CF_2]_nBr$ ;  
 $CF_3CF_2[OCF_2CF_2]_nH$ ;  $CF_3CHF[OCF_2CF_2]_nF$ ;  $CF_3CHF[OCF_2CF_2]_nCl$ ;  
 $CF_3CHF[OCF_2CF_2]_nBr$ ;  $CF_3CHF[OCF_2CF_2]_nH$ ;  $CF_3CHF[OCF_2CF(CF_3)]_nF$ ;  
 $(CF_3)_2CF(CF_2)_nF$ ;  $(CF_3)_2CF(CF_2)_nCl$ ;  $(CF_3)_2CFO(CF_2)_nBr$ ;  $(CF_3)_2CFO(CF_2)_nH$ ;  
 $(CF_3)_2CFO(CF_2)_nF$ ;  $(CF_3)_2CFO(CF_2)_nCl$ ;  $(CF_3)_2CFO(CF_2)_nBr$ ;  $(CF_3)_2CFO(CF_2)_nH$ ;  $C_nF_{2n+2}$ ;  
 $CF_3(CF_2)_nCl$ ;  $CF_3(CF_2)_nHCF_3(CF_2)_nBr$ ;  $N(C_nF_{2n+1})_3$  wherein n is 1 to 20;  $C_6F_mH_{6-m}$ ,  $C_6F_mCl_{6-m}$ ,  $C_6F_mBr_{6-m}$ ,  $C_6F_m(CF_3)_{6-m}$ , wherein m is 1 to 6; and mixtures thereof.

8. The method of claim 1, wherein:

the fluorinated solvent is selected from the group consisting of:

$CF_3(CF_2)_7Br$ ;  $(CF_3)_2CF(CF_2)_4Cl$ ;  $(CF_3)_2CFO(CF_2)_6F$ ;  
perfluorobutyltetrahydrofuran; perfluoropropyltetrahydropyran;  $C_8F_{18}$ ;  $CF_3CFBrCF_2Br$ ;  
 $(CF_3)_2CF(CF_2)_4Br$ ;  $[(CF_3)_2CFOCF_2CF_2]_2$ ;  $C_9F_{20}$ ;  $C_6F_6$ ;  $CF_3CHF[OCF_2CF(CF_3)]_3F$ ;  
 $(CF_3)_2CF(CF_2)_6Cl$ ;  $C_{10}F_{16}$ ;  $CF_3CHF[OCF_2CF(CF_3)]_4F$ ;  
perfluorotetrahydrodicyclopentadiene;  $[(CF_3)_2CFO(CF_2)_4]_2$ ; perfluorodecalin;  
 $CF_3CHF[OCF_2CF(CF_3)]_5F$ ; perfluorodimethyladamantane;  $N(C_4F_9)_3$ ;  
perfluoromethyldecalin;  $C_6H_4(CF_3)_2$ ; and  $CF_3CHF[OCF_2CF(CF_3)]_9F$ , and mixtures thereof.

9. The method of claim 1, wherein:

the fluorinated solvent is perfluorodecaline.

10. The method of claim 1, wherein:

the surfactant is selected from the group consisting of:

$F(CF_2CF_2)_y(CH_2CH_2O)_xH$ , wherein y is 1 to 10, and x is 0 to 25;  
 $((F(CF_2CF_2)_yCH_2CH_2)_xP(O)(ONH_4)_y)$ , wherein x is 1 or 2, y is 1 or 2, x + y is 3, and z is 1 to

8;  $\text{F}(\text{CF}_2\text{CF}_2)_x\text{CH}_2\text{CH}_2\text{SCH}_2\text{CH}_2\text{CO}_2\text{Li}$ , wherein  $x$  is 1 to 10;  $\text{F}(\text{CF}_2\text{CF}_2)_x\text{CH}_2\text{CH}_2\text{SO}_3\text{Y}$ , wherein  $x$  is 1 to 10, and  $\text{Y}$  is  $\text{H}^+$  or  $\text{NH}_4^+$ ; and mixtures thereof.

11. The method of claim 1, wherein:  
the surfactant is a mixture of  $\text{CF}_3(\text{CF}_2)_5\text{CH}_2\text{CH}_2\text{SO}_3\text{H}$  and  $\text{CF}_3(\text{CF}_2)_5\text{CH}_2\text{CH}_2\text{SO}_3\text{NH}_4$ .
12. The method of claim 1, wherein:  
the volume-to-volume ratio of fluorinated solvent to aqueous electrolyte in the emulsion is from 1:24 to 24:1.
13. The method of claim 1, wherein:  
the volume-to-volume ratio of fluorinated solvent to aqueous electrolyte in the emulsion is from 3:24 to 12:24.
14. The method of claim 1, wherein:  
the volume-to-volume ratio of fluorinated solvent to aqueous electrolyte in the emulsion is from 1:6 to 5:7.
15. The method of claim 1, wherein:  
the volume-to-volume ratio of fluorinated solvent to aqueous electrolyte in the emulsion is from 2:9 to 4:9.
16. The method of claim 1, wherein:  
The amount of surfactant in the emulsion is from 0.07% to 3% of the total weight of the emulsion.
17. The method of claim 1, wherein:

The amount of surfactant in the emulsion is from 0.125% to 2% of the total weight of the emulsion.

18. The method of claim 1, wherein:

The amount of surfactant in the emulsion is from 0.5% to 1% of the total weight of the emulsion.

19. The method of claim 1, wherein:

the gas comprises oxygen.

20. A composition for delivering gas and ions to an electrode, comprising:  
an emulsion comprising:

a fluorinated hydrocarbon;

a surfactant; and

an aqueous electrolyte with a pH of at most 4 or at least 9.

21. The composition of claim 20, wherein:

the aqueous electrolyte has a pH of at most 3.

22. The composition of claim 20, wherein:

the aqueous electrolyte has a pH of at most 1.

23. The composition of claim 20, wherein:

the aqueous electrolyte comprises a member selected from the group consisting of:

$\text{H}_2\text{SO}_4$ ,  $\text{HNO}_3$ ,  $\text{HClO}_4$ ,  $\text{H}_3\text{PO}_3$ ,  $\text{H}_3\text{PO}_4$ ,  $\text{HCl}$ ,  $\text{HBr}$ ,  $\text{HI}$ ,  $\text{CH}_3\text{CO}_2\text{H}$ ,  $\text{CCl}_3\text{CO}_2\text{H}$ ,  $\text{CF}_3\text{CO}_2\text{H}$ , and mixtures thereof.

24. The composition of claim 20, wherein:

the electrolyte comprises an aqueous solution of  $\text{H}_2\text{SO}_4$ .

25. The composition of claim 20, wherein:

the aqueous electrolyte has a pH of at most 10.

26. The composition of claim 20, wherein:

the aqueous electrolyte comprises a member selected from the group consisting of:

$\text{LiOH}$ ,  $\text{NaOH}$ ,  $\text{KOH}$ ,  $\text{Rb}(\text{OH})$ ,  $\text{CsOH}$ ,  $\text{Mg}(\text{OH})_2$ ,  $\text{Ca}(\text{OH})_2$ ,  $\text{Sr}(\text{OH})_2$ , and  $\text{Ba}(\text{OH})_2$ , and mixtures thereof.

27. The composition of claim 20, wherein:

the fluorinated solvent is selected from the group consisting of:

$(\text{C}_n\text{F}_{2n+1})\text{Si}(\text{OCH}_3)_3$ ;  $(\text{C}_n\text{F}_{2n+1})_2\text{Si}(\text{OCH}_3)_2$ ;  $(\text{C}_n\text{F}_{2n+1})\text{CH}_2\text{OC}(\text{O})\text{CH}_3$ ;  
 $\text{CF}_3[\text{OCF}_2\text{CF}_2]_n\text{OCF}_3$ ;  $\text{CF}_3[\text{OCF}_2\text{CF}_2]_n\text{OCF}_2\text{Cl}$ ;  $\text{CF}_3[\text{OCF}_2\text{CF}_2]_n\text{OCF}_2\text{Br}$ ;  
 $\text{CF}_3[\text{OCF}_2\text{CF}_2]_n\text{CF}_2\text{H}$ ;  $\text{CF}_3[\text{OCF}_2\text{CF}_2]_n\text{F}$ ;  $\text{CF}_3[\text{OCF}_2\text{CF}_2]_n\text{Cl}$ ;  $\text{CF}_3[\text{OCF}_2\text{CF}_2]_n\text{Br}$ ;  
 $\text{CF}_3[\text{OCF}_2\text{CF}_2]_n\text{H}$ ;  $\text{CF}_3\text{CF}_2[\text{OCF}_2\text{CF}_2]_n\text{F}$ ;  $\text{CF}_3\text{CF}_2[\text{OCF}_2\text{CF}_2]_n\text{Cl}$ ;  $\text{CF}_3\text{CF}_2[\text{OCF}_2\text{CF}_2]_n\text{Br}$ ;  
 $\text{CF}_3\text{CF}_2[\text{OCF}_2\text{CF}_2]_n\text{H}$ ;  $\text{CF}_3\text{CHF}[\text{OCF}_2\text{CF}_2]_n\text{F}$ ;  $\text{CF}_3\text{CHF}[\text{OCF}_2\text{CF}_2]_n\text{Cl}$ ;  
 $\text{CF}_3\text{CHF}[\text{OCF}_2\text{CF}_2]_n\text{Br}$ ;  $\text{CF}_3\text{CHF}[\text{OCF}_2\text{CF}_2]_n\text{H}$ ;  $\text{CF}_3\text{CHF}[\text{OCF}_2\text{CF}(\text{CF}_3)]_n\text{F}$ ;  
 $(\text{CF}_3)_2\text{CF}(\text{CF}_2)_n\text{F}$ ;  $(\text{CF}_3)_2\text{CF}(\text{CF}_2)_n\text{Cl}$ ;  $(\text{CF}_3)_2\text{CFO}(\text{CF}_2)_n\text{Br}$ ;  $(\text{CF}_3)_2\text{CFO}(\text{CF}_2)_n\text{H}$ ;  
 $(\text{CF}_3)_2\text{CFO}(\text{CF}_2)_n\text{F}$ ;  $(\text{CF}_3)_2\text{CFO}(\text{CF}_2)_n\text{Cl}$ ;  $(\text{CF}_3)_2\text{CFO}(\text{CF}_2)_n\text{Br}$ ;  $(\text{CF}_3)_2\text{CFO}(\text{CF}_2)_n\text{H}$ ;  $\text{C}_n\text{F}_{2n+2}$ ;  
 $\text{CF}_3(\text{CF}_2)_n\text{Cl}$ ;  $\text{CF}_3(\text{CF}_2)_n\text{HCF}_3(\text{CF}_2)_n\text{Br}$ ;  $\text{N}(\text{C}_n\text{F}_{2n+1})_3$  wherein  $n$  is 1 to 20;  $\text{C}_6\text{F}_m\text{H}_{6-m}$ ,  $\text{C}_6\text{F}_m\text{Cl}_{6-m}$ ,  $\text{C}_6\text{F}_m\text{Br}_{6-m}$ ,  $\text{C}_6\text{F}_m(\text{CF}_3)_{6-m}$ , wherein  $m$  is 1 to 6; and mixtures thereof.

28. The composition of claim 20, wherein:

the fluorinated solvent is selected from the group consisting of:

$\text{CF}_3(\text{CF}_2)_7\text{Br}$ ;  $(\text{CF}_3)_2\text{CF}(\text{CF}_2)_4\text{Cl}$ ;  $(\text{CF}_3)_2\text{CFO}(\text{CF}_2)_6\text{F}$ ;  
perfluorobutyltetrahydrofuran; perfluoropropyltetrahydropyran;  $\text{C}_8\text{F}_{18}$ ;  $\text{CF}_3\text{CFBrCF}_2\text{Br}$ ;

$(\text{CF}_3)_2\text{CF}(\text{CF}_2)_4\text{Br}$ ;  $[(\text{CF}_3)_2\text{CFOCF}_2\text{CF}_2]_2$ ;  $\text{C}_9\text{F}_{20}$ ;  $\text{C}_6\text{F}_6$ ;  $\text{CF}_3\text{CHF}[\text{OCF}_2\text{CF}(\text{CF}_3)]_3\text{F}$ ;  
 $(\text{CF}_3)_2\text{CF}(\text{CF}_2)_6\text{Cl}$ ;  $\text{C}_{10}\text{F}_{16}$ ;  $\text{CF}_3\text{CHF}[\text{OCF}_2\text{CF}(\text{CF}_3)]_4\text{F}$ ;  
 perfluorotetrahydrodicyclopentadiene;  $[(\text{CF}_3)_2\text{CFO}(\text{CF}_2)_4]_2$ ; perfluorodecalin;  
 $\text{CF}_3\text{CHF}[\text{OCF}_2\text{CF}(\text{CF}_3)]_5\text{F}$ ; perfluorodimethyladamantane;  $\text{N}(\text{C}_4\text{F}_9)_3$ ;  
 perfluoromethyldecalin;  $\text{C}_6\text{H}_4(\text{CF}_3)_2$ ; and  $\text{CF}_3\text{CHF}[\text{OCF}_2\text{CF}(\text{CF}_3)]_9\text{F}$ ; and mixtures thereof.

29. The composition of claim 20, wherein:  
 the fluorinated solvent is perfluorodecaline.

30. The composition of claim 20, wherein:  
 the surfactant is selected from the group consisting of:  
 $\text{F}(\text{CF}_2\text{CF}_2)_y(\text{CH}_2\text{CH}_2\text{O})_x\text{H}$ , wherein y is 1 to 10, and x is 0 to 25;  
 $((\text{F}(\text{CF}_2\text{CF}_2)_y\text{CH}_2\text{CH}_2)_x\text{P}(\text{O})(\text{ONH}_4)_y)$ , wherein x is 1 or 2, y is 1 or 2, x + y is 3, and z is 1 to 8;  
 $\text{F}(\text{CF}_2\text{CF}_2)_x\text{CH}_2\text{CH}_2\text{SCH}_2\text{CH}_2\text{CO}_2\text{Li}$ , wherein x is 1 to 10;  $\text{F}(\text{CF}_2\text{CF}_2)_x\text{CH}_2\text{CH}_2\text{SO}_3\text{Y}$ ,  
 wherein x is 1 to 10, and Y is  $\text{H}^+$  or  $\text{NH}_4^+$ ; and mixtures thereof.

31. The composition of claim 20, wherein:  
 the surfactant is a mixture of  $\text{CF}_3(\text{CF}_2)_5\text{CH}_2\text{CH}_2\text{SO}_3\text{H}$  and  
 $\text{CF}_3(\text{CF}_2)_5\text{CH}_2\text{CH}_2\text{SO}_3\text{NH}_4$ .

32. The composition of claim 20, wherein:  
 the volume-to-volume ratio of fluorinated solvent to aqueous electrolyte in the  
 emulsion is from 1:24 to 24:1.

33. The composition of claim 20, wherein:  
 the volume-to-volume ratio of fluorinated solvent to aqueous electrolyte in the  
 emulsion is from 3:24 to 12:24.

34. The composition of claim 20, wherein:

the volume-to-volume ratio of fluorinated solvent to aqueous electrolyte in the emulsion is from 1:6 to 5:7.

35. The composition of claim 20, wherein:  
the volume-to-volume ratio of fluorinated solvent to aqueous electrolyte in the emulsion is from 2:9 to 4:9.

36. The composition of claim 20, wherein:  
the amount of surfactant in the emulsion is from 0.07% to 3% of the total weight of the emulsion.

37. The composition of claim 20, wherein:  
the amount of surfactant in the emulsion is from 0.125% to 2% of the total weight of the emulsion.

38. The composition of claim 20, wherein:  
The amount of surfactant in the emulsion is from 0.5% to 1% of the total weight of the emulsion.

39. A fuel cell for the generation of electricity, comprising:  
a) an anode;  
b) a cathode; and  
c) a composition in contact with at least one of the anode and the cathode comprising:

an emulsion comprising a fluorinated solvent, a surfactant and an aqueous electrolyte with a pH of at most 4 or at least 9.

40. The fuel cell of claim 39, wherein:

the fuel cell is a fuel cell wherein the cathode and the anode are separated by a membrane.

41. The fuel cell of claim 39, wherein:

the anode and the cathode are separated by a channel contiguous with at least a portion of each electrode;

such that when a first liquid is contacted with the anode, a second liquid is contacted with the cathode, and the first and the second liquids flow through the channel, a parallel laminar flow is established between the first and the second liquid.

42. The fuel cell of claim 39, wherein:

the composition in contact with the anode further comprises a fuel.

43. The fuel cell of claim 39, wherein:

the composition in contact with the cathode further comprises oxygen.

44. In a fuel cell comprising:

a) an anode; and

b) a cathode;

the improvement comprising:

transporting a gas to at least one of the anode and the cathode by:

dissolving the gas in an emulsion comprising a fluorinated solvent, a surfactant and an aqueous electrolyte with a pH of at most 4 or at least 9; and

contacting the emulsion with at least one of the anode and the cathode.